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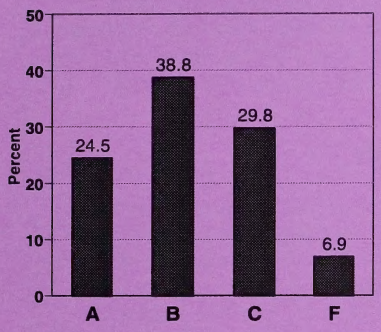
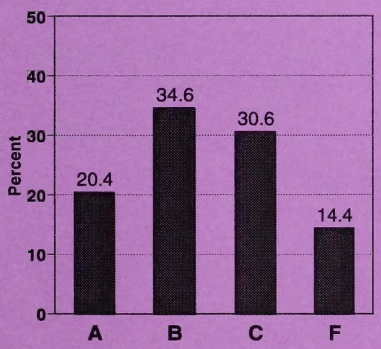
Chemistry 30

Diploma Examination Results
Examiners' Report for January 1998

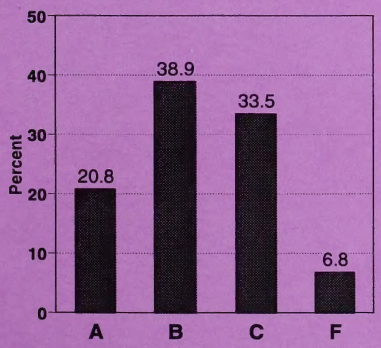
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the January 1998 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined November, January, June, and August results is published annually.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and two written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 6 892 students in Alberta who wrote the January 1998 examination. This represents a decrease of 58 compared with January 1997. It should be noted that just over 200 students wrote the Chemistry 30 diploma in November 1997. The combined November and January administrations represent an overall increase in the number of students writing the Chemistry Diploma Examination compared with the same period last year.

- 93.2% of the 6 892 students achieved the acceptable standard (a final course mark of 50% or higher).
- 20.8% of the students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 50.6% of the students who wrote the January 1998 examination were female.

- 93.6% of the female students achieved the acceptable standard (a final course mark of 50% or higher).
- 18.9% of the female students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 49.4% of the students who wrote the January 1998 examination were male.

- 92.7% of the male students achieved the acceptable standard (a final course mark of 50% or higher).
- 22.6% of the male students achieved the standard of excellence (a final course mark of 80% or higher).

Students First!
Student Evaluation

Alberta EDUCATION

Provincial Averages

- The average school-awarded mark was 68.8%.
- The average diploma examination mark was 65.9%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.7%.

Approximately 8.5% of the students who wrote the examination in January 1998 and received a school-awarded mark had written at least one other Chemistry 30 Diploma Examination during the January 1997 to January 1998 period. This sub-population (584) did not do as well on the examination (64.6%) as the population (6 308) who first wrote the Chemistry 30 examination (66.0%) in January 1998. However, the group of students who rewrote the chemistry examination increased their exam score, on average, by 14.8%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a minimum mark of 50%, and students capable of achieving the standard of excellence will obtain a minimum mark of 80%. The Chemistry 30 Examination requires students to apply their understanding of concepts to new situations in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer.

For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Quantitatively Predicting Outcomes
- GLE 2 Qualitatively Analyzing Systems
- GLE 3 Relationships in Energy Transfer
- GLE 4 Relationships in Electron Transfer
- GLE 5 Relationships in Equilibrium Systems
- GLE 6 Relationships in Proton Transfer

Skills:

- SPC Scientific Process and Communication Skills

Science, Technology, Society:

- STS Science, Technology, and Society Connections

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC1	C	0.583		✓	✓					
MC2	B	0.735	✓		✓				✓	
NR1	8.11	0.715	✓		✓				✓	
NR2	45.8	0.591	✓		✓				✓	
MC3	A	0.812	✓		✓				✓	
NR3	3142	0.630		✓	✓					
MC4	C	0.714	✓		✓				✓	✓
MC5	B	0.821		✓	✓					✓
MC6	A	0.824		✓	✓					✓
MC7	B	0.802	✓		✓				✓	✓
MC8	A	0.445	✓		✓				✓	✓
MC9	B	0.580		✓	✓				✓	✓
MC10	A	0.709		✓	✓				✓	✓
NR4	3214	0.760		✓	✓					✓
MC11	C	0.791	✓		✓				✓	✓

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
NR5	33.2	0.917	✓		✓				✓	✓
MC12	B	0.930		✓	✓					✓
MC13	A	0.807	✓		✓				✓	✓
NR6	62.9	0.664	✓		✓				✓	
MC14	B	0.757		✓		✓				✓
MC15	C	0.733		✓		✓			✓	
MC16	A	0.912		✓		✓			✓	
MC17	D	0.661	✓			✓			✓	
MC18	C	0.848		✓		✓			✓	
MC19	D	0.880		✓		✓			✓	
MC20	C	0.636		✓		✓			✓	✓
MC21	D	0.835		✓		✓				✓
MC22	B	0.661		✓		✓			✓	✓
MC23	B	0.616		✓		✓				✓
MC24	A	0.633	✓			✓			✓	✓
NR7	3.36	0.358	✓			✓			✓	✓
MC25	A	0.768		✓		✓				✓
MC26	D	0.550		✓		✓			✓	✓
NR8	18.4	0.305	✓			✓			✓	
NR9	2042	0.664	✓			✓			✓	
MC27	C	0.716		✓		✓			✓	✓
MC28	A	0.601		✓				✓		✓
MC29	B	0.424		✓				✓	✓	✓
MC30	C	0.547		✓			✓		✓	✓
MC31	D	0.852		✓				✓		✓
MC32	A	0.955	✓				✓		✓	✓
MC33	B	0.459	✓			✓			✓	✓
NR10	9.38	0.157	✓				✓		✓	✓
MC34	C	0.773	✓				✓		✓	✓
MC35	D	0.502		✓				✓		
MC36	D	0.964		✓				✓	✓	
MC37	A	0.725		✓			✓	✓	✓	
MC38	B	0.655		✓				✓		
MC39	C	0.857	✓					✓	✓	✓
MC40	*	0.871		✓				✓	✓	✓
MC41	A	0.721		✓				✓		
MC42	B	0.828	✓				✓		✓	
NR11	3142	0.479		✓			✓		✓	
NR12	3.07	0.853	✓				✓	✓	✓	✓
MC43	**	0.799						✓	✓	✓
MC44	C	0.343					✓	✓	✓	✓
WR 1	–	0.600		✓(12)		✓(8)			✓(4)	✓(12)
WR 2	–	0.533	✓(12)					✓(8)	✓(4)	✓(12)

* MC40: B if A was selected from MC39; A if B was selected; D if C was selected; and C if D was selected.

** MC43: B if answer to NR12 was ≥4.4; C if NR12 was 3.2<NR12<4.4; and D if NR12 was ≤3.2.

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored:	38.8 out of 56
Multiple-choice	31.7 out of 44
Numerical-response	7.1 out of 12
Written Response:	13.7 out of 24
Question 1	7.2 out of 12
Question 2	6.4 out of 12

Raw Score Average for Machine-Scored Items and Written-Response Questions by General Learner Expectation

General Learner Expectations		Total Exam		
GLE 1	Quantitatively Predicting Outcomes	22.4	out of	36
GLE 2	Qualitatively Analyzing Systems	30.1	out of	44
GLE 3	Relationships in Energy Transfer	13.9	out of	19
GLE 4	Relationships in Electron Transfer	16.6	out of	26
GLE 5	Relationships in Equilibrium Systems	5.7	out of	9
GLE 6	Relationships in Proton Transfer	13.4	out of	21
SPC	Scientific Process and Communication Skills	32.7	out of	49
STS	Science, Technology, and Society Connections	37.9	out of	59

Multiple-Choice and Numerical-Response Questions

The following table gives results for 4 questions selected from the examination. The table shows the percentage of students in four groups that answered the question correctly. The comments following the table discuss some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number			
Student Group	**MC 17**	**MC 35**	**NR 11**	**NR 10**
All Students	66.1	50.2	47.9	15.7
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	85.3	79.2	82.7	39.7
Students achieving the *acceptable standard* (between 50% and 79%, B or C) on the whole examination	63.5	46.8	44.8	9.8
Students who have not achieved the *acceptable standard* (49% or less, or F), on the whole examination	50.7	26.3	17.8	1.3

17. If the lithium reduction half-reaction, $Li^+_{(aq)} + e^- \rightarrow Li_{(s)}$, had been assigned an $E°$ value of 0.00 V, the predicted $E°_{net}$ value for the reaction $Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + Zn_{(s)}$ would be

A. +3.38 V
B. –2.28 V
C. –0.42 V
***D.** –1.10 V

Use the following information to answer the next question.

You have been given two unlabelled acidic solutions. One is a weak acid and one is a strong acid, but they have the same pH.

35. Which of the following statements about the two acids is true?

A. The weak acid more easily releases hydrogen ions and is more concentrated than the strong acid.
B. The strong acid more easily releases hydrogen ions and is more concentrated than the weak acid.
C. The weak acid more easily releases hydrogen ions and is less concentrated than the strong acid.
***D.** The strong acid more easily releases hydrogen ions and is less concentrated than the weak acid.

The following questions were selected for discussion because they exemplify the minimum requirements of the acceptable standard and of the standard of excellence.

Students achieving the acceptable standard, between 50% and 79%, were generally successful in answering questions such as multiple-choice questions 11, 14, 15, 17, 22, 24, 25, 27, and 34 and numerical-response question 4.

For example, in **multiple-choice question 17**, most students recognized that the relative net electrode potential for an oxidation–reduction reaction is not changed when a new standard half-cell is arbitrarily assigned.

A number of students (16.9%) unsuccessfully calculated the new electrode potential for the zinc half-reaction by adding 3.04 V and 0.76 V. These students proceeded to use this incorrect half-reaction voltage to determine the net cell potential.

The results from this question suggest that students who do not achieve the acceptable standard have difficulty performing routine chemistry calculations.

Students achieving the standard of excellence, 80% and higher, were generally successful in answering questions such as multiple-choice questions 8, 29, 33, 35 and numerical-response questions 7, 8, and 11.

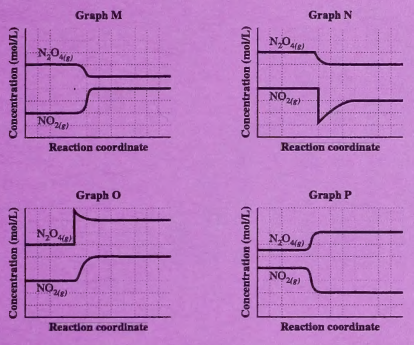
For example, in **multiple-choice question 35**, students achieving the standard of excellence showed an understanding of the differences between acid concentration and acid strength as well as an understanding of the relationship of acid concentration and acid strength to pH. A large percentage of students not achieving the standard of excellence assumed that acid concentration and acid strength

Use the following information to answer the next question.

The graphs below show the relative concentration of $N_2O_{4(g)}$ and $NO_{2(g)}$ as various stresses are exerted on the equilibrium system

$$N_2O_{4(g)} + \text{heat} \rightleftharpoons 2\ NO_{2(g)}$$

(Note: The graphs are not drawn to scale.)



Stresses: **1** removing $NO_{2(g)}$
2 cooling system
3 adding heat
4 adding $N_2O_{4(g)}$

Numerical Response

11. Match each of the graphs with the appropriate stress.

Graph M _____ (Record in column 1)
Graph N _____ (Record in column 2)
Graph O _____ (Record in column 3)
Graph P _____ (Record in column 4)

Answer: 3142

Use the following information to answer the next question.

$$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+{}_{(aq)} + NH_{3(aq)}$$

Numerical Response

10. In a system at equilibrium, the concentration of the $NH_{3(aq)}$ is 0.35 mol/L and the concentration of the $NH_4Cl_{(aq)}$ is 0.25 mol/L. The pH of the $NH_4^+{}_{(aq)}$ / $NH_{3(aq)}$ solution is _____.
(Record your answer to three digits on the answer sheet.)

Answer: 9.38

are the same, (i.e., strong acids are concentrated and weak acids are dilute).

Students at all levels correctly described strong acids as more easily dissociated than weak acids.

In **numerical-response question 11,** students achieving the standard of excellence were able to analyze and interpret graphical information. They recognized the points on the graphs where a stress was exerted and the subsequent equilibrium changes resulting from that stress. They were then able to relate these equilibrium changes to specific chemical changes imposed on the system.

These students exhibited a good understanding of Le Chatelier's principle and an ability to recognize causal relationships.

A number of students (17.8%) were able to analyze and interpret the graph and to relate the analysis to most of the stresses indicated. However, they had difficulty with the exothermic and endothermic changes and, as a result, transposed their answers.

The results from this question suggest that students who attained the standard of excellence did so because they were able to connect a series of conditions, changes, and results involving high-level thinking skills.

Numerical-response question 10 was generally answered very poorly. Only 15.8% of all students were able to calculate the pH of the system.

The three most common incorrect methods used to solve this question were:

1. Students assumed that the 1:1 ratio of the products could be used to determine the $[H_3O^+{}_{(aq)}]$.
   $[H_3O^+{}_{(aq)}] = [NH_{3(aq)}] = 0.35 mol/L$
   $= -\log 0.35 = 0.46$

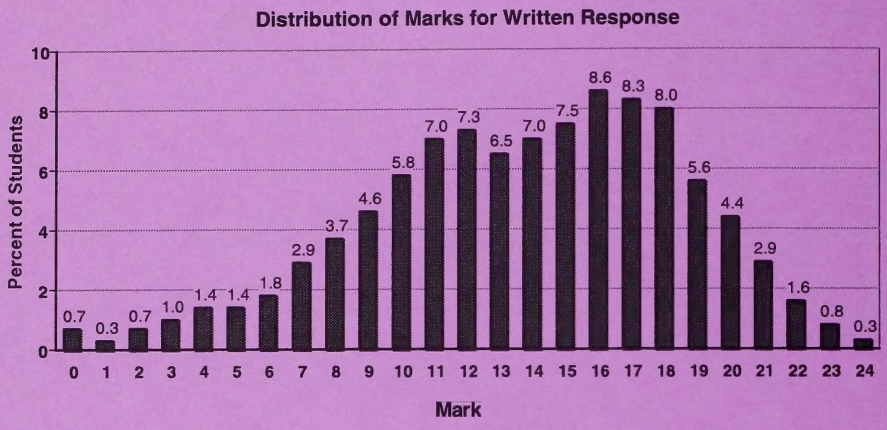
2. Students used the correct K_a value but inappropriate concentrations.
   $[H_3O^+{}_{(aq)}] = [NH_{3(aq)}] = \text{unknown}$
   $[H_3O^+{}_{(aq)}]^2 = 5.8 \times 10^{-10} \times 0.25$
   $pH = -\log [H_3O^+{}_{(aq)}]$

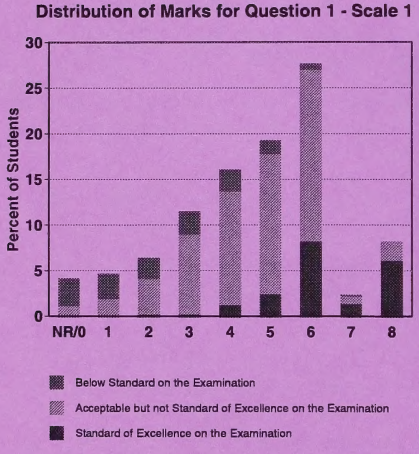
3. Students assumed that the K_a could be directly used to determine pH.
   $pH = -\log 5.8 \times 10^{-10} = 9.2$

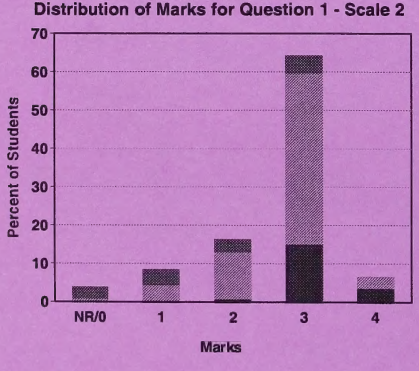
All students should be able to write an equilibrium expression for a given equation, and to substitute data into that equation. The results of this question suggest that students have difficulty identifying which chemical specie determines the pH of a solution.

Written-Response Questions

Of all the students who wrote the exam, 68.7% received a mark of 12 or higher out of 24 on the written-response questions. The average mark on the written-response questions was 13.7.







Written-response question 1 was answered better than expected. The question was selected to measure students' ability to quantitatively analyze titration data. Students were asked to verify the identity of an unknown base sample by applying their knowledge of acid–base chemistry.

Overall, students attempted all parts of the question. They were successful in averaging the volume of acid used and in using the average volume to solve for the moles of acid in the titration. Most students attempted to calculate the mass or molar mass for the unknown and to compare it with the values for strychnine.

A poor understanding of the term "dibasic" was the most common chemistry problem for students, as demonstrated by their use of an incorrect ratio in calculations.

Most students attempting to write an acid–base reaction in the analysis were unsuccessful. Students were unfamiliar with molecular bases, such as strychnine, which do not have a negative overall charge and form a positive charged specie when protonated. Students should be equally familiar with polybasic species and polyprotic species, as outlined in the 1995 Interim Chemistry 20–30 Program of Studies (page 51).

Students who did not achieve the acceptable standard averaged 2.7 on the chemistry content scale and 1.6 on the communication scale. Overall, they averaged 4.3 by calculating the net volume for each of the titration trials and demonstrating an understanding of the method to determine the moles of acid by using n=Cv or the moles of base by using n=m/M. The question was not attempted by 7.9% of the students not achieving the acceptable standard.

Students made errors substituting values into equations while attempting to calculate the molar mass of strychnine, and they also used acid volumes indiscriminately. These students seldom discarded the second titration trial and commonly did not average the acid–volume trials. Students had difficulty completing basic stoichiometry calculations. Few wrote an acid–base reaction or made any reference to an acid–base ratio when analyzing the data. These omissions illustrate a limited understanding of titration analysis. Some students failed to recognize the question as a stoichiometry problem and attempted to calculate or describe pH or Ka to verify the base identity. Students not achieving the acceptable standard consistently exhibited poor organizational and communication skills. Insufficient attention to detail, especially with respect to significant digits and units, contributed to their failure to perform simple mathematical calculations correctly.

Students who did achieve the acceptable standard but not the standard of excellence on the examination averaged 4.5 on the chemistry content scale and 2.7 on the communication scale for an overall average of 7.2 on the question. These students correctly calculated the volume for each trial, discarded the appropriate trial(s), and averaged the resulting two or three volumes. They calculated both the moles of acid and the moles of base. The students demonstrated a good understanding of acid–base stoichiometry for a 1:1 acid–base titration problem. They reached the correct conclusion but sometimes based their decision on an incorrect analysis; i.e., they could generate a valid chemistry comparison but the mole ratio used resulted in inaccurate analysis values. Some students digressed to "pH confusion" assuming that [base] =[OH^-]. A number of students performed a percent error calculation to defend their decision. Units and states on interim calculations were frequently not included. A common significant digit error was the recording of 28.7 mL as the average volume rather than 28.70 mL. Generally, these students' responses were well organized.

Students who achieved the standard of excellence were expected to score 10 or better. They averaged 6.4 on the chemistry content scale and 3.1 on the communication scale. On the first scale, 30.7% attaining a perfect score and on the second scale, 19.4% attained a perfect score. Overall, they averaged 9.5 by accurately employing the 2:1 mole ratio in the analysis calculations. The ratio was often implied by the calculated values but not stated explicitly. Even students at the standard of excellence had difficulty generating a balanced equation for this acid–base reaction. It should be noted, however, that an equation was not required for full marks to be awarded. Students at the standard of excellence demonstrated an ability to accurately analyze data of an unfamiliar reagent, and they often provided more than one method to dismiss strychnine as the base used in the titration. These students exhibited excellent attention to detail in terms of organizational and communication skills, with clear and concise responses.

On this 12-mark question, the average mark was 7.2.

Written-response question 2 was selected to measure students' understanding of corrosion protection using principles of oxidation–reduction chemistry. Students were required to explain in chemical terms how the corrosion-prevention components worked and to identify relevant half-reactions.

Overall, students were familiar with appropriate chemistry terms such as sacrificial anode, cathodic protection, and oxidizing agent, although they were not always able to explain what the terms meant chemically. Many students ignored the plastic component of the tape and its role in corrosion prevention.

Students who did not achieve the acceptable standard averaged 0.9 out of 4 on the chemistry content scale, which resulted in a content mark of 1.8 out of 8. These students averaged 1.0 on the communication scale. Overall they averaged 2.8 out of 12 on the question because students recognized that the question was related to oxidation–reduction chemistry and understood that the tape somehow prevented corrosion or rusting of the iron pipe. Students identified magnesium as the specie responsible for protecting the iron but were unable to explain the mechanism. Many of these students attempted to write half–reactions and were successful in writing one for the oxidation of magnesium. Their responses were unclear as to how the magnesium would protect the iron pipe. Many students wrote reactions with $Fe^{2+}_{(aq)}$ as the strongest oxidizing agent and converted it into $Fe_{(s)}$ as a viable corrosion prevention method. Another misconception was that water alone would

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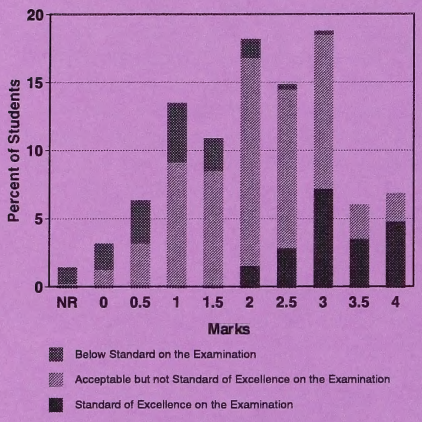
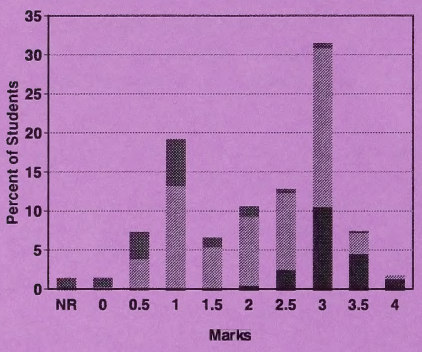
Distribution of Marks for Question 2 - Scale 1



Distribution of Marks for Question 2 - Scale 2



oxidize the iron. A number of students focused on how to prevent rusting caused by a reaction between iron and the contents flowing through the pipe rather than that caused by a reaction between iron and species found underground. These student responses were poorly organized and contained many errors in conventions. Students commonly used ion and metal states interchangeably. This question was not attempted by 7.8% of the students not achieving the acceptable standard.

Students who achieved the acceptable standard but not the standard of excellence averaged 2.05 out of 4 on the chemistry content scale, which resulted in a content mark of 4.1 out of 8. These students averaged 2.1 on the communication scale. Overall, they averaged 6.2 out of 12 on the question because they identified magnesium as the strongest reducing agent and provided appropriate support for their choice. They demonstrated confidence in their understanding of oxidation–reduction chemistry concepts. Students used valid oxidation half-reactions and explained how magnesium acted as a sacrificial anode. These students tended to focus on one key factor affecting corrosion prevention and did it well. Many students utilized an electrochemical cell diagram to support their explanations. Some students identified other possible species found in soil that could oxidize iron, for example, aqueous copper ions. A common misconception held by a number of students was the suggestion that a water and magnesium reaction would occur before the water and iron reaction, thereby preventing the pipe from corrosion. The most common omission was that of the water–oxygen half-reaction as the strongest reducing agent primarily responsible for the oxidation of the iron pipe. These students' responses were generally well organized. Errors in convention such as states of matter and spelling were fairly common.

Students who achieved the standard of excellence averaged 3.15 out of 4 on the chemistry content scale, which resulted in a content mark of 6.3 out of 8. These students averaged 2.8 on the communication scale. On the first scale, 23.9% attained a perfect score and on the second scale, 7.0% attained a perfect score. Overall, they averaged 9.1 out of 12 on the question. Students achieving the standard of excellence did so because they could successfully identify the two components of the tape and because their responses indicated a good understanding of the reaction mechanism including the oxygen–water reduction half-reaction. Some students inferred that the function of the plastic tape was to act as a barrier and they did not specifically address it as a corrosion-prevention technique. Many of these students recognized that iron forms a precipitate with hydroxide, $Fe(OH)_{2(s)}$. These students presented their answers in a succinct, well-written, and organized manner with small errors primarily in conventions.

On this 12-mark question, the average mark was 6.4.

For further information, contact Marlene McDonald (mmcdonald@edc.gov.ab.ca) or Corinne McCabe cmccabe@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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